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SYSTEM ANALYSIS OF THE ENTIRE TOPOGRAPHIC SUPPORT SYSTEM (TSS).(U)
AUG 78 R S COLOMBO, C T GOLDSMITH, A MACEIKO DAAK70-77-C-0275
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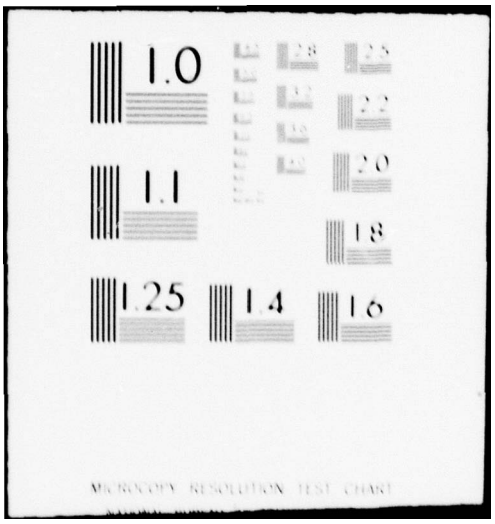
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Report DAAK-70-77-C-0275
ETL-0158

SYSTEM ANALYSIS OF THE ENTIRE TOPOGRAPHIC SUPPORT SYSTEM (TSS)

DECILOG, INC.
555 Broadhollow Road
Melville, NY 11746

30 August 1978

Final Report

Prepared for:

U. S. ARMY
Engineer Topographic Laboratories
Fort Belvoir, VA 22060

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An Interim Report on this program, dated 15 July 1978, concluded, among other things, that the Topographic Support System (TSS) configuration, agreed to by the Integrated Equipment Evaluation Team (IEET) at its June 1978 meeting, should be simulated. In addition, it was recommended that this new simulation have the capability of varying the number of personnel in the TSS to resolve staffing problems. This has been accomplished, and the results are contained in this report.

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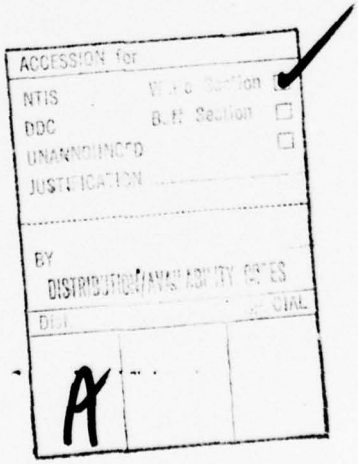
The previously simulated TSS configurations contained a maximum of 26 Modules, while the IEET recommended a total of 34. Engineer Topographic Laboratories personnel recommended changes to the previously used Product List and Procedures Lists. These changes generally had the effect of decreasing Production times.

At an interarrival rate of three requests per hour, the system performed very well in most product categories, and adequately in all others. Almost 73% of all requested products had been completed at the end of 144 hours. Only the Copy Camera had a significant queue.

The simulation was then run again with a 33% reduction in personnel, and performed equally well. Overcapacity was found in several equipment areas.

The simulation was also run at an interarrival rate of two requests per hour, and, at the end of 144 hours, almost 86% of all requests had been completed. This represents almost all which could have been completed if products had no competition. Overcapacity also increased.

It is concluded that the IEET-recommended TSS will produce products and services rapidly in a combat environment. It is noted, however, that the approximately 50% increase in Module count resulted in a 25% increase in throughput over the previously simulated TSS reconfiguration, which introduced some product orientation into the system.



1.0 Management Overview

The Interim Report on this program, dated 15 July 1978, concluded, among other things, that the Topographic Support System (TSS) configuration, agreed to by the Integrated Equipment Evaluation Team (IEET) at its June 1978 meeting, should be simulated. In addition, it was recommended that this new simulation have the capability of varying the number of personnel in the TSS to resolve staffing problems. This has been accomplished, and the results are contained in this report.

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TABLE OF CONTENTS

2.0 Introduction

The Interim Report on this program[1] concluded that the System configuration as of January 1978 had rather severe deficiencies. This System configuration, as presented to Decilog, consisted of 23 operational Modules. During the study reported in reference 1, the Module count was increased to 26 by doubling Drafting, Rectifier I and Camera. Although throughput increased, it was still not acceptable.

2.1 Background

During the IEET meeting of June 1978, the Module count was increased significantly to a total of 34 Modules, some of which were "new" in that the contained equipments not previously included. Specifically, in the Cartographic Revision (CR) and Image Based Products (IBP) Subsystems, a total of eleven Modules were added to the original 23, resulting in a total of 30 operational Modules. The Drafting Subsystem was completely redesigned and a modified Rectifier I and Rectifier II added to Image Based Products.

Additionally, staffing problems were uncovered in the study described in the Interim Report.

For all of these reasons, the Engineer Topographic Laboratories requested that Decilog simulate the June 1978 TSS configuration, and include in the simulation the ability to vary the staffing within Modules. In addition, ETL made changes in the previous Product List and Procedure Lists. These are discussed in detail in Section 3 of this report, but, in general, they had the effect of reducing the throughput times for several Product Categories, and reducing the percentage of occurrence of some Products which are time consuming to produce.

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(1) DAAK-70-77-C-0275-1. System Analysis of the Entire Topographic System. Interim Report. Decilog, Inc. 15 July 1978.

Finally, ETL requested that the TSS be simulated at interarrival times of Requests at rates less than three per hour. This Report, therefore, presents the results of the simulation of the TSS under the following conditions:

- June 1978 configuration; T.O.E. personnel; interarrival time three requests per hour.

- June 1978 configuration; altered personnel; interarrival rate three requests per hour

- June 1978 configuration; T.O.E. personnel; interarrival rate two requests per hour.

The reasons that the simulations were restricted to these combinations will become obvious in the next subsection. It should be noted that the assumptions used in Reference (1) are unchanged in these simulations.

2.2 Results

The first simulation run was the June 1978 configuration; T.O.E. personnel at three requests per hour. At the end of 144 hours, almost 72% of all requests that had been entered into the TSS had been completed. This is certainly adequate performance. Only the Copy Camera in Camera had a significant queue. Although the Light Table in Synthesis had high utilization, it was not a bottleneck, and a simple change could be implemented to reduce its utilization. More importantly, overcapacity in both equipment and personnel was uncovered.

With respect to personnel overcapacity, it was noted that, in many Modules, more personnel were assigned than there were major pieces of equipment. For this reason, the simulation was run again with one person assigned per major equipment. This was a reduction of 36 persons, or approximately 33% of the total TSS operational personnel. At the end of 144 hours, almost 73% of all requests which had entered the TSS had been completed. That is, the system performed equally well with a 33% reduction in personnel. Since the criterion used for assignment was one

person per major equipment, it was felt there would be nothing to be gained from further reductions. The details of personnel reduction are discussed in Section 4 of this report.

Finally, the request rate was reduced to two per hour with the original personnel compliment. (The results would have been the same with the 33% personnel reduction). At the end of the 144 hours, almost 86% of all requests which had entered the TSS had been completed. Based on the specific requests entered during the last 16 hours of the simulation, it was possible to calculate the maximum percentage which could possibly have been completed, assuming no simultaneous demands. It was found that 90% of all requests would have been completed had there been no competition among requests. Thus, at the rate of two requests per hour, the TSS is performing very well. Naturally, overcapacity increased.

2.3 Conclusions

1. It is concluded that the 34 Module TSS agreed to by the IEET will perform adequately in the field. Mean Processing Times are given in Section 4 of this Report.

2. The IEET changes to T.O.E. personnel can be reduced by 33%, assuming personnel within a Module are cross-trained on all equipments in the Module.

3. Overcapacity exists in many Modules within the System. For example, one of the Mosaicking Modules in CR could be eliminated without affecting throughput. Further details of overcapacity are discussed in Section 4.

4. The approach taken by the IEET in redesigning the TSS appears to be "brute force". The approximately 50% increase in Module count resulted in only a 25% improvement over a slightly reconfigured System previously simulated.

5. There can be little doubt that a system design which would be somewhat more "product oriented" should perform as well or

better than the June 1978 "process-oriented" configuration with fewer Modules. This would result in decreased cost, decreased vulnerability of the TSS, greater flexibility in deployment, and increased efficiency.

3.0 Changes to TSS Configuration and Model

3.1 P.C.L.

The P.C.L. (Proposed Component List) used in this simulation was the June 1978 TSS configuration. This configuration includes the changes made by the IEET in the June 1978. The following lists describe the TSS configuration used:

- List I - listing of the TSS modules and their numerical designations.
- List II - listing of the TSS equipment and their numerical designations.
- List III - listing of the changes made to the January 1978 TSS configuration that produced the June 1978 TSS configuration used in this simulation.
- List IV - listing of the procedure times assigned to each piece of equipment and their associated procedural descriptions. The times are organized by using the equipments' numerical designations.

The lists described above, follow:

LIST I

TSS MODULE DESIGNATIONS - VERSION C

	Numerical Designations
C & C Subsystem -	
A. Operations Module	VAN #1
SRD Subsystem -	
A. Distribution Module	VAN #2
B. Storage/Retrieval Module	VAN #3
MGI Subsystem -	
A. Information Module	VAN #4
B. Collection Module	VAN #5
C. Analysis Module	VAN #6
D. Synthesis Module	VAN #7
CR Subsystem -	
A. Drafting Support Module	VAN #8
B. I.G.S. Module (not used)	VAN #9
C. Compilation Modules (2)	VAN #10
D. Mosaic/Drafting Modules (3)	VAN #11
IBP Subsystem -	
A. Rectifier I Modules (2)	VAN #12
B. Rectifier II Modules (2)	VAN #13
C. Mosaic/Drafting Modules (2)	VAN #14
REPRO Subsystem -	
A. Finishing Module	VAN #15
B. Map Layout Module	VAN #16
C. Photomechanical Module	VAN #17
D. Plate Processing Module	VAN #18
E. Camera Module	VAN #19
F. Press Module I	VAN #20
G. Press Module II	VAN #21
H. Press Module III	VAN #22
I. Press Module IV	VAN #23

LIST I (Cont'd)

	Numerical Designations
SURVEY Subsystem -	
A. Survey Module	VAN #24

LIST II

TSS EQUIPMENT CONTENT - VERSION C

	Numerical Designations
SRD Subsystem -	
A. Distribution Module	VAN #2
1. Files (std. maps)	(2-1)
B. Storage/Retrieval Module	VAN #3
1. Rolodex Card Files (2)	(3-1)
2. Files (repromats, film)	(3-2)
3. Wrapper	(3-3)
4. IBM Card Punch	(3-4)
5. Production Status Board	(3-5)
MGI Subsystem -	
A. Information Module	VAN #4
1. Rolodex Card File	(4-1)
2. Files	(4-2)
3. Diazo Printer	(4-3)
4. Desk Top Copiers (2)	(4-4)
B. Collection Module	VAN #5
1. Facsimile Machine	(5-1)
C. Analysis Module	VAN #6
1. APPS (+ HP-9830 + Plotter)	(6-1)
2. Light Table/Split Stage	(6-2)
3. Photointerpreter's Desks (2)	(6-3)
4. Zoom Transfer Scope	(6-4)
5. Diazo Printer	(6-5)
6. Drawing Board	(6-6)
7. Stereoscopes (2)	(6-7)
D. Synthesis Module	VAN #7
1. Diazo Printer	(7-1)
2. Typewriter	(7-2)
3. Light Tables (3)	(7-3)
4. Viewer/Printer	(7-4)

LIST II (Cont'd)

	Numerical Designations
CR Subsystem -	
A. Drafting Support Module	VAN #8
1. Drafting Table	(8-1)
2. Light Table	(8-2)
3. Coordinatograph	(8-3)
4. Pin Register Board	(8-4)
5. Phototypesetter	(8-5)
B. I.G.S. Module (not used)	VAN #9
1. Interactive Graphics Systems (2)	(9-1)
C. Compilation Modules (2)	VAN #10
1. Zoom Transfer Scopes (3)	(10-1)
2. Tracing Tables (4)	(10-2)
D. Mosaic/Drafting Modules (3)	VAN #11
1. Tracing Tables (4)	(11-1)
IBP Subsystem -	
A. Rectifier I Modules (2)	VAN #12
1. Printer/Enlarger	(12-1)
2. Automatic Film/Paper Processor	(12-2)
3. Frame Rectifier	(12-3)
4. Panoramic Rectifier	(12-4)
5. Tracing Table	(12-5)
6. Printer Contact Processor	(12-6)
B. Rectifier II Modules (2)	VAN #13
1. APPS (+ HP-9830 + Plotter)	(13-1)
2. Tracing Tables (2)	(13-2)
C. Mosaic/Drafting Modules (2)	VAN #14
1. Tracing Tables (4)	(14-1)

LIST II (Cont'd)

	Numerical Designations
REPRO Subsytem -	
A. Finishing Module	VAN #15
1. Wrapper	(15-1)
2. Binder/Stapler	(15-2)
3. Paper Cutter	(15-3)
B. Map Layout Module	VAN #16
1. Litho Layout Tables (4)	(16-1)
2. Pin Register Board	(16-2)
C. Photomechanical Module	VAN #17
1. Photo Processing Machine	(17-1)
2. Litho Layout Table	(17-2)
3. Plate Finishing Tables (2)	(17-3)
4. Vacuum Frame	(17-4)
5. Litho Processing Sinks (2)	(17-5)
6. Platemaker	(17-6)
D. Plate Processing Machine	VAN #18
1. Platemaker	(18-1)
2. Litho Processing Sinks (2)	(18-2)
3. Plate Finishing Tables (2)	(18-3)
4. Litho Layout Table	(18-4)
E. Camera Module	VAN #19
1. Copy Camera	(19-1)
2. Litho Processing Sink	(19-2)
F. Press Module I	VAN #20
1. Offset Press	(20-1)
G. Press Module II	VAN #21
1. Offset Press	(21-1)
H. Press Module III	VAN #22
1. Offset Press	(22-1)
I. Press Module IV	VAN #23
1. Offset Press	(23-1)

LIST II (Cont'd)

	Numerical Designations
SURVEY Subsystem -	
A. Survey Module	VAN #24
1. Survey Equipment Set (3)	(24-1)

LIST III

CHANGES TO TSS CONFIGURATION - VERSION C

MGI - Analysis

a) Zoom Transfer Scope added
b) Stereoscope added
c) Two Photointerpreter's Desks added

MGI - Synthesis

a) Typewriter added
b) Drawing Board deleted
c) Reflecting Projector deleted

CR - Drafting functions are now performed in the Drafting Support Module and the three Modaic/Drafting Modules

CR - Compilation

a) Instead of one, there are now two Compilation Modules
b) Two Zoom Transfer Scopes added
c) Tracing Table added

IBP - Rectifier I

a) Instead of one, there are now two Rectifier I Modules
b) Printer Contact Processor added

IBP - Rectifier II

a) Instead of one, there are now two Rectifier II Modules
b) Tracing Table deleted

IBP - Orthophoto Module deleted

IBP - Mosaic/Drafting

a) Instead of one, there are now two Mosaic/Drafting Modules

REPRO - Map Layout

a) Two Litho Layout Tables deleted

LIST III (Cont'd)

REPRO - Photomechanical

a) Two Plate Finishing Tables added
b) Diazo Printer deleted

REPRO - Plate Processing

a) Litho Layout Table added

LIST IV

TSS EQUIPMENT & PROCEDURE TIMES - VERSION C

EQUIPMENT NUMERICAL DESIGNATION		TIME (SECONDS)	PROCEDURE
(C & C)	a)	600	Mean supervisor conversation length
	b)	1500	Verbal explanation
	c)	5000	Mean production planning time
	d)	900	Quality assurance
	e)	1800	Quality assurance
(2 - 1)	a)	240 ± 120	Locate item to retrieve
		5	Retrieve item
		180 ± 30	Prepare item for transit
(3 - 1)	a)	180 ± 60	Perform lookup
(3 - 2)	a)	240 ± 120	Locate item to retrieve
		5	Retrieve item
		180 ± 30	Prepare item for transit
(3 - 3)	a)	180 ± 30	Wrap item
(3 - 4)	a)	120 ± 15	Utilize IBM Card Punch
(3 - 5)	a)	120 ± 15	Utilize Production Status Board
(4 - 1)	a)	180 ± 60	Perform lookup
(4 - 2)	a)	180 ± 60	Locate item to retrieve
		5	Retrieve item
(4 - 3)	a)	30	Copy
(4 - 4)	a)	60	Copy
(5 - 1)	a)	300 ± 60	Receive transmission
(6 - 1)	a)	900 ± 300	Setup & calibrate on known points
		900 ± 300	Determine first point coordinates
		480 ± 120	Determine additional coordinates
(6 - 2)	a)	180 ± 60	Tabulate point coordinates
(6 - 3)	a)	1800 ± 600	Analyze photography
(6 - 4)	a)	1200 ± 300	Setup Zoom Transfer Scope
		21600 ± 3600	Compile
(6 - 5)	a)	30	Copy

LIST IV (Cont'd)

EQUIPMENT NUMERICAL DESIGNATION		TIME (SECONDS)	PROCEDURE
(6 - 6)	a)	1800 ± 600	Perform drafting
(6 - 7)	a)	900 ± 300	Analyze stereophoto
(7 - 1)	a)	30	Copy
(7 - 2)	a)	360 ± 60	Type page
(7 - 3)	a)	7200 ± 3600	Utilize Light Table
	b)	25200 ± 3600	Utilize Light Table
	c)	72000 ± 7200	Utilize Light Table
(7 - 4)	a)	1200 ± 600	Utilize Viewer/Printer
(8 - 1)	a)	32400 ± 3600	Perform drafting
(8 - 2)	a)	14400 ± 7200	Perform inspection
(8 - 3)	a)	18000 ± 3600	Superpose grid
		3600 ± 900	Plot horizontal control
(8 - 4)	a)	1500 ± 300	Register photo
(8 - 5)	a)	7200 ± 3600	Perform typesetting
(9 - 1)	a)	21600 ± 3600	Perform drafting
	b)	1800	Setup drafting task
		1800 ± 600	Prepare & enter marginal data
		1800 ± 600	Perform rough plotting
		1800 ± 600	Edit
		3600 ± 900	Emulate scribing
		3600 ± 900	Prepare peel coats
	c)	1800	Setup drafting task
		4500 ± 900	Prepare & enter marginal data
		1800 ± 600	Perform rough plotting
		1800 ± 600	Edit
		10800 ± 2700	Emulate scribing
		7200 ± 1800	Prepare peel coats
	d)	1800	Setup drafting task
		1800 ± 600	Prepare & enter marginal data
		1800 ± 600	Perform rough plotting
		1800 ± 600	Edit
		1800 ± 600	Perform final plotting
	e)	1800	Setup drafting task
		4500 ± 900	Prepare & enter marginal data
		1800 ± 600	Perform rough plotting
		1800 ± 600	Edit
		1800 ± 600	Perform final plotting
	f)	1800	Setup drafting task
		10800 ± 3600	Prepare marginal overlay

LIST IV (Cont'd)

EQUIPMENT NUMERICAL DESIGNATION		TIME (SECONDS)	PROCEDURE
(10 - 1)	a)	1200 ± 300	Setup Zoom Transfer Scope
		21600 ± 3600	Compile
(10 - 2)	a)	14400 ± 7200	Perform inspection, compilation
(11 - 1)	a)	43200 ± 7200	Perform drafting
	b)	1800	Setup drafting task
		9000 ± 1800	Draft special overlay
		12600 ± 1800	Perform ink lettering
		7200	Prepare overlay peel coats
		5400 ± 900	Inspect & edit overlay
	c)	1800	Setup drafting task
		25200 ± 3600	Draft special overlay
		12600 ± 1800	Perform ink lettering
		10800 ± 3600	Prepare overlay peel coats
		9000 ± 1800	Inspect & edit overlay
	d)	1800	Setup drafting task
		9000 ± 1800	Draft special overlay
		7200	Perform ink lettering
		5400 ± 900	Inspect & edit overlay
	e)	1800	Setup drafting task
		25200 ± 3600	Draft special overlay
		10800 ± 3600	Perform ink lettering
		9000 ± 1800	Inspect & edit overlay
	f)	1800	Setup drafting task
		14400 ± 7200	Prepare marginal overlay
(12 - 1)	a)	450 ± 150	Expose film
		120 ± 60	Expose film (additional exposures)
(12 - 2)	a)	360 ± 60	Process film
(12 - 3)	a)	1800 ± 600	Plot control points
		1800 ± 600	Rectify photo
(12 - 4)	a)	1800 ± 600	Plot control points
		1800 ± 600	Rectify photo
(12 - 5)	a)	180 ± 60	Inspect photo
(12 - 6)	a)	360 ± 60	Process film
(13 - 1)	a)	900 ± 300	Setup & calibrate on known points
		900 ± 300	Determine first point coordinates
		480 ± 120	Determine additional coordinates
(13 - 2)	a)	180 ± 60	Tabulate point coordinates

LIST IV (Cont'd)

EQUIPMENT NUMERICAL DESIGNATION		TIME (SECONDS)	PROCEDURE
(14 - 1)	a)	14400 ± 3600	Assemble uncontrolled mosaic
	b)	28800 ± 5400	Assemble controlled mosaic
	c)	21600 ± 3600	Assemble semicontrolled mosaic
(15 - 1)	a)	180 ± 30	Perform wrapping
(15 - 2)	a)	240 ± 60	Perform binding
(15 - 3)	a)	120 ± 30	Perform cutting operation
(16 - 1)	a)	1200 ± 300	Perform frame inspection
	b)	5400 ± 1800	Assemble mosaic
(16 - 2)	a)	1500 ± 300	Register frame
(17 - 1)	a)	360 ± 60	Process sheet
(17 - 2)	a)	300 ± 60	Check sheet
(17 - 3)	a)	120 ± 30	Perform inspection
(17 - 4)	a)	180 ± 60	Expose film
(17 - 5)	a)	600 ± 30	Process frame
(17 - 6)	a)	300 ± 60	Expose plate
(18 - 1)	a)	300 ± 60	Expose plate
(18 - 2)	a)	600 ± 300	Process plate
(18 - 3)	a)	120 ± 30	Finish plate
(18 - 4)	a)	120 ± 30	Perform inspection
(19 - 1)	a)	2250 ± 450	Expose film (no filter)
		600	Additional exposures (no filter)
	b)	7200	Expose film (filter)
		3600	Additional exposures (filter)
(19 - 2)	a)	600 ± 300	Process frame
(20 - 1)	a)	2700 ± 900	Setup offset press
		1 (per copy)	Print specified number of copies
		2700 ± 900	Dry printed products

LIST IV (Cont'd)

EQUIPMENT NUMERICAL DESIGNATION		TIME (SECONDS)	PROCEDURE
(21 - 1)	a)	2700 ± 900	Setup offset press
		1 (per copy)	Print specified number of copies
		2700 ± 900	Dry printed products
(22 - 1)	a)	2700 ± 900	Setup offset press
		1 (per copy)	Print specified number of copies
		2700 ± 900	Dry printed products
(23 - 1)	a)	2700 ± 900	Setup offset press
		1 (per copy)	Print specified number of copies
		2700 ± 900	Dry printed products
(24 - 1)	a)	10800 ± 3600	Travel to survey site
		21600 ± 7200	Perform survey
		10800 ± 3600	Travel from survey site

3.2 Product List and Percentages

The product list catalogs the products which can be produced by the TSS in this simulation. This list is the result of careful study of the DMA List of Approved Products and of consultation with ETL. Along with the listed products are their percentages of occurrence. The percentage of occurrence for a product coincides with the expected user demand for that product.

The product list used in this simulation includes some changes in product descriptions and percentages of occurrence made by ETL. The following is the product list used in the simulation of the June 1978 TSS configuration.

PRODUCT - PRIMARY CATEGORY	PER CENT OCCURRENCE
(1) Cartographic Products - Single Level	50
(2) Cartographic Products - Multi-Level	20
(3) Photographic Products - Single Level	10
(4) Photographic Products - Multi-Level	5
(5) Verbal Information - and/or Explanation	7
(6) Textual Information -	5
(7) Bound Volume Information -	1
(8) Special Print Request -	2

PRODUCT - PRIMARY CATEGORY #1

Cartographic Products - Single Level

Product - Secondary Category	Per Cent Occurrence	Associated Attributes
(1) Standard Map -	70	A,B,C
(2) Overprinted Standard Map - Using overlay from SRD	3	A,C,D
(3) Overprinted Standard Map - Using overlay from MGI	10	A,C,D
(4) Overprinted Standard Map - Using special MGI overlay (ie. Helicopter Landing Zones)	5	A,C,D
(5) Overprinted Standard Map - Using special MGI overlay (ie. Cross Country Movement)	3	A,C,D
(6) Non-Standard Map - scale change & selective omission (ie. contours omitted)	7	A,C,D
(7) Standard Map - with selective omissions using overprint with MGI. Subdued base one overlay & MGI data	2	A,C,D

PRODUCT - PRIMARY CATEGORY #2

Cartographic Products - Multi-Level

Product - Secondary Category	Per Cent Occurrence	Associated Attributes
(1) Standard Map - Single overlay obtained from SRD	5	A,C,D
(2) Standard Map - Single overlay compiled in MGI	10	A,C,D
(3) Standard Map - Four factor overlays obtained from SRD & interpretation performed in MGI	50	A,C,D
(4) Standard Map - Four factor overlays obtained from SRD, interpretation performed in MGI, & cartographic enhancement in CR	15	A,C,D
(5) Standard Map - With special MGI overlay (ie. Helicopter Landing Zones)	8	A,C,D
(6) Standard Map - With special MGI overlay (ie. Cross Country Movement)	2	A,C,D
(7) Non-Standard Map - Scale change, MGI overlay with information, & compilation in CR	10	A,C,D

PRODUCT - PRIMARY CATEGORY #3

Photographic Products - Single Level

Product - Secondary Category	Per Cent Occurrence	Associated Attributes
(1) Standard Photos - Using unrectified frame photographs (9"x9" format)	8	A,C,D
(2) Standard Photos - Using unrectified 3" panoramic photographs	2	A,C,D
(3) Uncontrolled Photomosaic - Standard map size using 9"x9" frame photography	10	A,C,D,E
(4) Semi-Controlled Mosaic - Controlled photo mosaic of a standard map area using frame photography	20	A,C,D,E
(5) Photomap - Standard map size using 9"x9" frame photography	10	A,C,D,E
(6) Special Enlarged Photo - Photographically annotated with information from MGI	10	A,C,D
(7) Photos with control points - Manually annotated horizontal control points, 9"x9" format including APPS position coordinates (90% APPS, 10% SURVEY)	30	A,C,D

(8)	Photos with control points - Annotated horizontal control points, 9"x9" format including APPS position coordinates, also with MGI annotation	9	A,C,D
(9)	Uncontrolled Photomosaic - Using unrectified panoramic photos	1	A,C,D,E

PRODUCT - PRIMARY CATEGORY #4

Photographic Products - Multi-Level

Product - Secondary Category	Per Cent Occurrence	Associated Attributes
(1) Standard Photo Map - Single overlay obtained from SRD	20	A,C,D
(2) Standard Photo Map - Single overlay obtained from MGI	20	A,C,D
(3) Standard Photo Map - Single overlay obtained from SRD & interpretation performed in MGI	20	A,C,D
(4) Standard Photo Map - Single overlay obtained from SRD & two overlays from MGI	10	A,C,D
(5) Standard Photo Map - Single overlay obtained from SRD, two overlays obtained from MGI & interpretation performed by MGI	10	A,C,D
(6) Non-Standard Photo Map - Using overlay information obtained from MGI & drafting performed by CR	10	A,C,D

(7) Standard Photo Map - Using overlay information obtained from MGI & drafting performed by CR	10	A,C,D

PRODUCT - PRIMARY CATEGORY #5

Verbal Information and/or Explanation

This category is slightly different than those previously mentioned. This category was designed to simulate an activity that would occur in the Operations Module. Namely, the distribution of verbal information to a "customer".

Since the standard analysis of conversation length has been found to be well represented by an exponential distribution, we have selected such a distribution with a mean value of 25 minutes to represent the transmission of information verbally.

PRODUCT - PRIMARY CATEGORY #6

Textual Information

Product - Secondary Category	Per Cent Occurrence	Associated Attributes
(1) Standard Bulletin - Retrieved from MGI information	50	A,B,C
(2) Standard Trig. List -	20	A,B,C
(3) Special Report - Special 5-page report prepared by MGI	30	C,D

PRODUCT - PRIMARY CATEGORY #7

Bound Volume Information

Product - Secondary Category	Per Cent Occurrence	Associated Attributes
(1) Standard Maps - reduce scale, 8½"x11" format	5	A,C,D
(2) Standard Maps - reduce scale, 8½"x11" format, including point position detail and trig. lists	20	A,C,D
(3) Standard Maps - reduce scale, 8½"x11" format, special purpose overlay and text from MGI	75	A,C,D

PRODUCT - PRIMARY CATEGORY #8

Special Print Request

Product - Secondary Category	Per Cent Occurrence	Associated Attributes
(1) Standard Map - Produce 1000 copies of a map using repromat from SRD	20	C
(2) Standard Map - Produce 1000 copies of a map with revisions	80	C

3.3 Procedure Lists

The procedure lists describe the step-by-step process that each product request must follow in order to become a finished product. In the procedure lists, each step of the production process is represented by a piece of equipment and a description of how the equipment was utilized. Thus, after entering the TSS, a product request is routed along the production path, predetermined by the equipment assignments that are specified by the procedure lists.

The procedure lists for this simulation are contained in Appendix A.

4.0 Results

This section will concentrate on reporting the results of the simulation of the June 1978 TSS configuration. In addition, however, some comparisons with previously simulated configurations are included for comparison purposes.

In interpreting these results, it is important to keep in mind the underlying assumptions, which are described in detail in Reference 1. Perhaps the most important of these is that the TSS is simulated operating in a European "SCORES" environment. This is very intense, short duration, combat. In a peacetime situation, or, in a longer duration, less intense combat situation, the results might differ.

4.1 Overall Results

The June 1978 configuration of the TSS was simulated under three sets of conditions, as follows:

1. 3 requests/hour, IEET, T.O.E.
2. 2 requests/hour, IEET, T.O.E.
3. 3 requests/hour, 33% reduction in personnel

The results are presented in Table 4-1. The columns labeled "C-1", "C-2", and "C-3" correspond to the three conditions listed above. The 1-8 row entries are the Primary Product categories, and the entries for each column show the number of requests received during 144 hours ("IN"), the number completed by 144 hours ("OUT"), and the percent completed (%). The last row shows the total throughput, in terms of requests received versus those completed in 144 hours.

TABLE 4-1

JUNE 1978 CONFIGURATION SYSTEM THROUGHPUT

	VRS: C-1			VRS: C-2			VRS: C-3		
	IN	OUT	O/O	IN	OUT	O/O	IN	OUT	O/O
1	236	186	78.8	149	130	87.25	235	183	77.87
2	89	63	70.8	50	44	88.00	89	63	70.79
3	33	14	42.4	18	13	72.22	34	15	44.12
4	22	14	63.6	13	12	92.31	22	15	68.18
5	23	23	100	16	16	100	23	23	100
6	22	14	63.6	11	10	90.91	22	15	68.18
7	2	0	0	2	0	0	2	0	0
8	9	3	33.3	7	3	42.86	9	4	44.44
T	436	317	72.7	266	228	85.71	436	318	72.94

A comparison of C-1 with C-3 shows that a 33% reduction in total operating technical personnel, from 131 to 68 persons, did not change total throughput. The reduction was based on the assumption that all personnel within a Module are cross-trained on all equipment in the Module. One person was then assigned to each major equipment. Table 4-2 indicates where the reductions in staff were made.

TABLE 4-2

REDUCTION IN OPERATIONAL, TECHNICAL PERSONNEL

	T.O.E. (JUNE 1978) PERSONNEL MODULES	REDUCED PER ASSUMPTIONS	REDUCTION
Distribution	3	2	-1
Storage/Retrieval	5	3	-2
Information	6	2	-4
Collection	6	1	-5
Analysis	6	4	-2
Synthesis	6	5	-1
Drafting Support	6	4	-2
Compilation	6 x 2	4 x 2	-2
Mosaicing	6 x 3	4 x 3	-2
Rectifier I	6 x 2	4 x 2	-2
Rectifier II	6 x 2	3 x 2	-3
Mosaicing	6 x 2	4 x 2	-2
Finishing	4	2	-2
Map Layout	6	4	-2
Photomechanical	5	4	-1

TABLE 4-2 (Cont'd)

	T.O.E. (JUNE 1978) PERSONNEL MODULES	REDUCED PER ASSUMPTIONS	REDUCTION
Plate Processing	5	4	-1
Camera	4	2	-2
Press	3 x 4	3	-
Survey	6	6	-

Since one person per equipment had been used, it is apparent that further personnel reductions would result in decreased throughput, therefore, no further reductions were simulated.

Returning to Table 4-1, a comparison of C-1 with C-2 indicates that the percentage of completed products rose from approximately 73% at an input rate of three per hour to approximately 86% at a rate of two requests per hour.

The Average Residence Time within the TSS was then calculated. Then, starting from the 144 hour "snapshot" and working backwards in time, the last input request to arrive at the TSS, which could possibly have been completed, was determined. As it happened, at 144-16 hours, or, at approximately the 128th simulated hour, a Primary Product Category 3 was requested. This product could have been completed (Mean Residence Time) in approximately 13 hours. No subsequent request could possibly have been completed, since the requests simply arrived too close in time to 144 hours.

From this, the maximum percentage of requests which could possibly have been completed was calculated. This calculation resulted in finding that 90% of all requests which were received in 144 hours could have been completed in 144 hours.

The actual percentage of completed products, 86%, can then be compared with the maximum possible, of 90%, to get an absolute measure of system throughput efficiency. System Efficiency is:

$$\frac{86}{90} = 94.6\%$$

which is very impressive performance. For this reason, request rate was not further reduced.

4.2 System Capacity

Since the total Module count was up to 34 Modules, a detailed analysis was carried out, looking not only for undercapacity, which was perdominant in the simulations described in Reference 1, but also, locations of overcapacity. These results are all based on an input rate of three requests per hour.

4.2.1 Undercapacity

The only really significant area of undercapacity was found to be the Copy Camera in the Camera Module. Despite the fact that the Product List and some Procedures were changed, the Copy Camera had a utilization of almost 80%, and a queue of 27 jobs at the end of 144 hours. This compares with a utilization of 95% and a queue of 21 jobs in the original January 1978 TSS configuration. The decreased utilization is due to the changes in Product List and Procedures, while the increased queue is due to the more rapid prior processing of requests, which results in them getting to the Copy Camera earlier.

The result with the Copy Camera has been consistant throughout all TSS simulations run. In light of this, it is difficult to interpret the IEET's recommendation to utilize only one Copy Camera. One user stated that, if his "back was against the wall" he would never use the Copy Camera, but, instead, provide alternate Products which would not require its use. If this could be generalized to the user community, it is possible that, based on prior experience, a "fall back" position has been adpoted by the

IEET as the design criterion, rather than an attempt to alleviate a problem.

The other two areas of undercapacity are, for practical purposes, insignificant. In the Drafting Module, the utilization of the drafting tables is high, almost 64%, but with a queue of only six jobs, it is not creating any bottlenecks. Furthermore, an intelligent Supervisor would probably route some of these jobs to the Mosaicking Modules in CR, which are somewhat underutilized, probably eliminating any queue.

Finally, in Map Layout, an additional Pin Register Board would alleviate a queue, which contains only a few jobs, but which, due to its long time duration, adversly affects Press operations.

4.2.2 Overcapacity

Based on the assumption of the SCORES scenario, considerable overcapacity was found. It is emphasized that this overcapacity may be desireable in a peacetime operation. For example, in MGI, there is a Diazo machine in each of the Analysis, Synthesis and Information Modules. All are underutilized. However, in a peacetime operation, these Modules might conceivably be so distant from one another as to make sharing inconvenient, if not impossible. Considerations of this type should be kept in mind in evaluating the following results.

Table 4-3 lists overcapacity by equipments.

TABLE 4-3

OVERCAPACITY - JUNE 1978 TSS CONFIGURATION

	NUMBER	UTILIZATION (%)
ANALYSIS		
Photointerpretive Desk	2	6.5
Stereoscope	2	3.2

TABLE 4-3 (Cont'd)

	NUMBER	UTILIZATION (%)
COMPILATION		
Zoom Transfer Scope	6	5.6
Tracing Table	8	3.3
RECTIFIER I		
Printer/Enlarger	2	13.2
Automatic Film Processor	2	29.6
Frame Rectifier	2	16.4
Tracing Table	2	0.6
RECTIFIER II		
APPS	2	25.0
Tracing Table	4	0.8
MOSAICKING (IBP)		
Tracing Table	8	11.7
MAP LAYOUT		
Litho Layout Table	4	3.3
PHOTOMECHANICAL		
Litho Layout Table	2	0.7
Litho Processing Sink	2	8.7
PLATE PROCESSING		
Litho Processing Sink	2	9.5
Plate Finishing Table	2	1.9
PRESS - IV		
Press	1	12.2

Recommendations with respect to the above instances of under- and overcapacity will be found in Section 5 of this report.

4.3 Comparison with Previous Simulations

Table 4-4 presents a comparison of the June 1978 TSS configuration with configurations previously simulated and reported upon in Reference 1. All configurations were simulated at a rate of three requests per hour. Version C-1 is the June 1978 configuration and has a total throughput of 72.7% of all requests in a 144 hour period.

Version A-1 is the January 1978 configuration with a total of 26 Modules. Version A-2 includes 29 Modules, doubling Drafting, Rectifier I and Camera.

Version B-1 is the Decilog modified configuration, introducing product orientation in certain photographic processes and continuing 29 Modules. Version B-2 substitutes an Interactive Graphics System for one Drafting Module and adds an Analytical Stereoplotter to the Orthophoto Module, continuing with 29 Modules. The reduced throughput of Version B-2 with respect to B-1 is directly attributable to the assumption that a digital data base would not be available for the Interactive Graphics.

Clearly, the C-1 version is superior to all others, but at a cost of five additional Modules. Table 4-5 shows the relative improvement of the various configurations simulated at the rate of three requests per hour. It can be seen that the June 1978 configuration shows an improvement of 23.75% over the Decilog-modified configuration with some slight product orientation, at a cost of five additional Modules. Since the Decilog modified version shows an increase of almost 18% over the original configuration, augumented to 29 Modules, with no increase in Module count, it is possible that product orientation is a higher payoff direction than merely increasing Modules in a process-oriented direction.

TABLE 4-4 COMPARISON OF VARIOUS TSS CONFIGURATIONS

	VRS: A-1			VRS: A-2			VRS: B-1			VRS: B-2			VRS: C-1		
	IN	OUT	O/O	IN	OUT	O/O	IN	OUT	O/O	IN	OUT	O/O	IN	OUT	O/O
1	222	143	63.6	230	147	63.9	230	152	66.1	234	144	61.5	236	186	78.8
2	54	18	33.3	58	21	36.2	55	38	69.1	63	35	55.6	89	63	70.8
3	24	1	4.2	25	2	8.0	31	12	38.7	32	12	37.5	33	14	42.4
4	21	0	0	22	1	4.5	21	0	0	22	0	0	22	14	63.6
5	11	11	100	11	11	100	11	11	100	11	11	100	23	23	100
6	5	4	80	5	4	80	5	4	80	5	4	80	22	14	63.6
7	12	0	0	13	0	0	13	1	7.7	14	0	0	2	0	0
8	48	25	52.1	49	20	40.8	51	27	52.9	53	28	52.8	9	3	33.3
T	400	202	50.5	413	206	49.9	417	245	58.8	434	234	53.9	436	317	72.7

TABLE 4-5

% IMPROVEMENT RELATIVE TO CONFIGURATIONS SIMULATED

	VRS: C-1	VRS: B-1	VRS: B-2	VRS: A-1	VRS: A-2
VRS: A-1	43.97	16.34	6.77	---	---
VRS: A-2	45.77	17.79	8.1	1.25	---
VRS: B-1	23.75	---	---	---	---
VRS: B-2	34.85	8.97	---	---	---
VRS: C-1	---	---	---	---	---

5.0 Conclusions and Recommendations

Based both on the results of the simulations conducted on both the January 1978 configuration and its reconfigurations, and also the simulations of the June 1978 configuration, the following conclusions and recommendations are offered:

1. The June 1978 TSS configuration can be considered a quick-reaction system at an input rate of two requests per hour.

2. It is probable that a product-oriented configuration, rather than the current process-oriented configuration, will result in a reduced Module count, reduced vulnerability, lower cost, greater flexibility in deployment and increased efficiency.

3. The technical, operation staffing from the June 1978 IEET changes to the T.O.E. can be reduced by 33% without effecting throughput efficiency.

4. An additional Copy Camera should be added to the TSS.

5. An additional Pin Register Board should be added to Map Layout.

6. Many of the Modules will be quite crowded with equipment and personnel, therefore, every attempt to reduce equipment which represents overcapacity should be made. These include (with comments):

   a) Up to two Diazo Machines in MGI if it is reasonable to move from Module to Module to share a common machine.
   b) One Photointerpretive Desk and Stereoscope from Analysis Module.
   c) One Zoom Transfer Scope from each Compilation Module.
   d) Two Tracing Tables from each Compilation Module.

e) One Printer/Enlarger from one of two Rectifier I Modules.

f) One Frame Rectifier from one of two Rectifier I Modules.

g) One Tracing Table from one of two Rectifier I Modules.*

h) One Tracing Table each from both Rectifier II Modules.

i) Two Tracing Tables each from both Mosaicing Modules (IBP).

j) Two Litho Layout Tables from Map Layout Module.

k) One Litho Layout Table and one Litho Processing Sink from Photomechanical Module.

l) One Plate Finishing Table and one Litho Processing Sink from Plate Processing Machine.

m) One Press Module, unless it is desirable from a reliability standpoint.

7. Since the TSS must support many roles (eg. short-term, high intensity combat, longer term, lower intensity combat, and peacetime functioning) the tool of simulation should be utilized, not only for pseudo-optimizing the system design for one role, but also for maximizing the flexibility inherent in modularity.

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* NOTE: Items e) through g) reflect the layout of a Module and then mere doubling of the Module. Equipment could be more logically grouped.